Available online at www.sciencedirect.com

ScienceDirect

Journal of Biomedical Informatics 41 (2008) 675–682

Journal of Biomedical Informatics

www.elsevier.com/locate/yjbin

Methodological Review

Value of the electronic patient record: An analysis of the literature

Aykut M. Uslu [a,*], Jürgen Stausberg [b]

[a] Uslu Medizininformatik, Consultant, Rembrandstr. 15, 40237 Düsseldorf, Germany

[b] Institute for Medical Informatics, Biometry and Epidemiology, Medical Faculty, University of Duisburg-Essen, Germany

Received 27 January 2007

Available online 15 February 2008

Abstract

We undertook a systematic review of the literature on the basis of published studies on the benefit and costs of Electronic Patient Records (EPRs) to clarify the issue of whether and to what extent the use of an EPR is worthwhile. We carried out a systematic electronic search for articles published between 1966 and early 2004 using MEDLINE, following up cross-references from the articles found. We searched first for suitable medical subject headings (MeSH) for electronic patient record, benefit and costs. We obtained 7860 citations with the MeSH keyword "Medical Record System, Computerized". After combination with appropriate keywords this number was reduced to 588, after a review by two reviewers independently based on abstracts down to 95, and after a further review based on full-text articles to 19 covering 20 studies. The publications evaluated thus document the economic benefits of EPR in a number of areas, but they do not make a statement of the cost effectiveness of EPR in general.

Keywords: Medical Record System, Computerized; Technology Assessment, Biomedical; Quality of Health Care; Benefits Costs; Cost Savings; Cost Effectiveness

1. Introduction

Rapid progress within the IT field makes the problems of paper-based patient documentation all the more apparent. It can be available only in one place at a time and it is often poorly organized. Documents may be incomplete or illegible, data may be acquired redundantly, and stored at different sites. Moreover, there is a high personnel and space requirement for the routing, archiving and maintenance of the paper-based patient documents. One thing is certain: the conventional paper-based patient record is rapidly reaching its limits [1].

Several systematic reviews related to IT use in health care have been done in the last five years. One of the most significant is the systematic review "Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care" that was prepared by Chaudry et al. [2]. They argue, among other things, that "Given the fragmented nature of health care, the large volume of transactions in the system, the need to integrate new scientific evidence into practice, and other complex information management activities, the limitations of paper-based information management are intuitively apparent". Another interesting review, "Costs and Benefits of Health Information Technology", which was prepared by Shekelle et al. [3] and provided Chaudry et al. [2] with a basis, assesses several statements on the economic value of a health information technology (HIT) and electronic health record (EHR) systems. It asserts that some organizations have already made major gains through the implementation of multifunctional, interoperable HIT systems built around an EHR. A further review "Electronic Patient Records: Moving from Islands and Bridges towards Electronic Health Records for Continuity of Care" prepared by Knaup et al. [4] asserts that changes in the media, processes and attitudes are necessary to move from historic paper-based representation through islands of EPR systems and bridges for communication to continuous

* Corresponding author. Fax: +49 211 2304801.

E-mail addresses: aykut@uslumedizininformatik.de (A.M. Uslu), stausberg@ekmed.de (J. Stausberg).

1532-0464/$ - see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.jbi.2008.02.001

high-quality patient care supported by comprehensive electronic health records.

As an alternative, both the quantifiable as well as the non-quantifiable advantages of an EPR compared with a paper-based one are receiving ever more attention among experts. However, the numerous positive representations of an EPR that have been published are not yet compelling enough. The question as to whether the benefits outweigh the costs awaits a clear answer. On the basis of an analysis of published studies of the benefits and costs of the EPR, this paper explores the available evidence based on empirical results.

2. Materials and methods

2.1. Study identification

Previously published empirical studies on EPR in a hospital environment constitute the basis of this paper. The studies were required to document the costs and/or the use of EPR in hospital environment with figures. They must also be available in either German or English. The publication date within the used literature database was not restricted. A procedure plan that described the individual steps and criteria was drawn up beforehand. The literature search took place from 10 December 2003 to 15 January 2004 by using MEDLINE (1966-January 2004). The access to the MEDLINE database was exclusively made by the German Institute for Medical Documentation and Information (DIMDI) in the Internet (http://www.dimdi.de/).

2.2. Study selection

First of all, we acquired the following suitable keywords of medical subject headings (MeSH) from the National Library of Medicine (NLM) for electronic patient record, benefit and costs:

- *Electronic Patient Record*: Medical Record System, Computerized. Moormann and van der Lei [5] also deemed this MeSH-Term "the central item".
- *Benefit*: Outcome Assessment, Patient; Outcome Study; Quality of Health Care.
- *Cost*: Benefits Costs; Cost Analysis; Cost Benefit; Cost Effectiveness; Cost Savings; Cost, Health Care; Costs and Analysis.
- *Cost and Benefit*: Technology Assessment, Biomedical.

Afterwards, the MeSH "Medical record system, Computerized" was searched. The results were successively combined by AND-conjunction with the other keywords. Duplicates were deleted in the results as well as non-English and non-German publications, reviews, tutorials and review tutorials leaving 588 studies (see Table 1).

An examination of the relevance of these 588 studies for the question took place in two stages. In the first stage the studies were evaluated independently by two reviewers (both authors) on the basis of the abstracts. The evaluation criteria were specific statements about the EPR, its origination in a clinical environment, and a publication based on an empirical study. Initially the plan was that publications had to fulfill the stages two to five of the definition of the EPR according to Peter Waegemann [6] shown in Table 2. After a detailed analysis of the studies it was decided to accept the definition used by each study itself. This resulted in 117 studies for further literature procurement.

Twenty two of the 117 selected publications were not accessible, i.e. the publications were not available in German libraries and had to be purchased from abroad. The remaining 95 were examined independently in the second stage on the basis of the full texts by the same reviewers, based on specific statements about benefits and costs.

The conclusion of this appraisal procedure left 21 publications that were taken into the analysis process. In the context of the further analysis, it was concluded that two articles were unsuitable because they did not fulfill one of the criteria from the first or second stage, and hence they

Table 1
Hit of citations

Terms	Number of citations
Medical Record System, Computerized	7860
Combined with	
Outcome Assessment, Patient	152
Outcome Study	152
Quality of Health Care	187
Combined with	
Benefits Costs	149
Cost Analysis	78
Cost Benefit	149
Cost Effectiveness	149
Cost Savings	95
Cost, Health Care	35
Costs and Cost Analysis	78
Combined with	
Technology Assessment, Biomedical	29
Total	1253
Total without duplicates	588

Table 2
Development levels of EPR according to Waegemann [6]

1. Automated Medical Record: paper-based patient record with an additional part of documents which is computer-generated
2. Computerized Medical Record: medical record, which was made completely electronically available via scanning of all not computer-generated documents with the same content and structure as in the first stage
3. Electronic Medical Record: medical record, which was obtained from the second stage by restructuring and optimized for computer processing with same contents as the first two stages by hospital wide interoperability of all documentation systems
4. Electronic Patient Record: patient-centred record with information about different supplying facilities and thus considerably extended contents
5. Electronic Health Record: by Wellness relevant data of the patient extended record, which is obtained from the fourth stage

Table 3
Survey of evaluated studies

Number of study	Study	Year	Institution	Participant	Running period	Statement to costs	Statement to benefits
1	Antoine [10]	2002	Six internist. Clinics of a private hospital owner	65 physicians—45 residents and 20 faculty members	22 months (over 1.5 year)	P	x
2	Asher [11]	2003	A midsize hospital	35 physicians and 160 employees	4 weeks	P	x
3	Blair [12]	2003	A otolaryngology special clinic chain of a private hospital owner	Five physicians with a sixth on the way, one nurse, six audiologists and 40 office staff in three locations	1 year	P	No statements
4	Fleisher [13]	1997	Emergency department of a Children's Hospital	More than 100 Emergency Department staff physicians (between five and 12 physicians for a given shift throughout the day)	No statements	P	No statements
5	Fox [14]	1998	Two special clinics of a large hospital	Over 1500 password registered clinical users	3 years	P	No statements
6	Hammond et al. [15]	1991	Burn Center of a university hospital	No statements	3 years	P	P
7	Kahl et al. [16]	1991	57 bed nursing unit of a midsize hospital	35 hospital members	No statements	P	No statements
8	Kian et al. [17]	1995	Cancer Center of a university hospital	About 8000 employees	10 years	P	No statements
9	Marill et al. [18]	1999	Emergency department of a university-affiliated hospital	15 physicians and 1228 patients	1 year	P	No statements
10	Myers et al. [19]	2000	19 regional clinics of a integrated health care system	circa 1600 authorized people	6 years	P	No statements
11	Neubauer et al. [20]	2001	Ophthalmic hospital of a university hospital	40 workstations	1 Year	N	No statements
12	Pierpont and Thilgen [21]	1995	Cardiologic intensive care unit of a university hospital	60 nursing staff	3 Monate	P	x
13	Sandrick 1 [22]	1998	Diagnostic clinic of a integrated health care system	No statements	No statements	P	No statements
14	Sandrick 2 [22]	1998	Trauma surgery department of a university hospital	No statements	1 year	P	No statements
15	Sands et al. [23]	1998	36 clinics of a midsize hospital	653 providers of which 76 percent were physicians	1 year	P	No statements
16	Smith [24]	1997	A midsize hospital	32 user	4 months	P	No statements
17	Tierney et al. [25]	1993	Emergency department and intensive care unit of a urban public hospital	A total of 5219 internal medicine patients and the 68 teams of house officers, medical students, and faculty internists who cared for them	17 months	P	No statements
18	Wall [26]	1998	intensive care unit of a midsize hospital	No statements	1 year	P	No statements
19	Wells et al. [27]	2003	Family Medicine Department of a university hospital	47 patient care providers and 241 patients	6 months	P	No statements
20	White and Hemby [28]	1997	Intensive care unit of a midsize hospital	Physicians and nursing staff of the intensive care unit	18 months	P	No statements

P, positive, i.e. reduction of costs; N, negative, i.e. no reduction of costs; x, positive, numerical unseizable value.

were excluded from evaluation. Another article considered two cases at once, and so these were treated as two individual studies. The end result was that 20 studies were evaluated further. These studies are listed in Table 3. In place of the author names, the numbers assigned in this table are used in the following when appropriate.

Inter-rater reliability during study selection was checked by calculating Cohen's Kappa with the interpretation of Landis and Koch [7]. In the first stage based on abstracts, the Kappa value was 0.26 indicating a fair agreement between the reviewers, while in the second stage based on full texts the Kappa value was 0.36 that also indicated a fair agreement.

2.3. Study evaluation

The criteria we used to evaluate the studies are based on the publication of Johnston et al. [8]. The following

Table 4
Classification of study designs according to Roine et al. [9]

1. Meta-analyses of randomized controlled trials
2. Large-sample randomized controlled trials
3. Small-sample randomized controlled trials
4. Non-randomized controlled prospective studies
5. Non-randomized controlled retrospective trials
6. Cohort studies
7. Case control studies
8. Non-controlled clinical series, descriptive studies, consensus methods
9. Anecdotes or case reports

five criteria were employed: (1) study design, (2) formal quality of publication, (3) number of users, (4) duration of implementation, and (5) statistical evaluation. Each quality criterion was evaluated with 2, 1 or 0 points, so that each study could thus reach at most 10 points. If no data concerning the quality criteria were available, this is indicated by "n.i." (no indication). The quantification of the determined quality criteria to points was undertaken as follows in detail.

2.3.1. Study design

The assessment of the study design was based on the criteria in Table 4, which follows Roine et al. [9]. There, different types of scientific studies are indicated descending after the evidence hierarchy, represented in 9 stages. The first stage of this table, meta-analyses from randomized, controlled studies, is not a component of the inclusion criteria. The remaining study types were combined into the following three groups: randomized controlled studies (evidence stages 2 and 3), non-randomized controlled studies (evidence stages 4–7), and uncontrolled clinical series, descriptive studies, consensus methods, application observations and empirical reports (evidence stages 8 and 9). Studies in the first group received 2 points, studies in the second group 1 point, and the remaining studies 0 point.

2.3.2. Formal quality of the publication

The publication should follow the internationally recognized structure of scientific articles, viz title (the author's name and institution), abstract, introduction, materials and methods, results, discussion, conclusions (and perspective view), references. For continuous compliance with this structure 2 points were assigned, for observance up to introduction and denomination of the author and the place of accruement 1 point, and if one of the data items concerning abstract, materials and methods, results, conclusion and references was ignored, then 0 points.

2.3.3. Number of users

The number of users can affect the reliability of the results. Therefore, 2 points were given for studies with 20 or more users, 1 point for 6–19, and 0 point for less then six users or if a number was not stated.

2.3.4. Duration

Studies implemented for at least one year received 2 points, 1 point was given for a half to one year, and 0 point for less than a half year.

2.3.5. Statistical evaluation

Evaluation and rating of scientific statements gain in evidential strength with statistical statements. For execution of statistical tests with full information concerning the level of significance 2 points were given, for the description of a statistical test done without indication of the level of significance 1 point, with missing execution and/or missing data concerning a statistical test 0 point.

3. Results

With the exception of one study from Germany, the majority of publications are in the USA, predominantly from large hospitals. All the studies deal with economic aspects, only four consider additionally the impact of EPR installation on the quality of care. All the studies with the exception of the German study show a direct economic benefit. The sole study that demonstrates a positive impact of the quality of care operates methodically at a medium level, the remaining three give at least positive indices, even if without numerical evidence.

3.1. Origin and location of the studies

The majority are from the United States, which comprise 19 of the 20 studies selected for evaluation. Europe is represented only by a single study carried out in Germany; South America, Asia, Africa and Australia are completely missing. Texas predominates with five studies, two each from Houston and Temple, a further one is from El Paso. The remaining American studies are two each from Massachusetts, South Carolina and Florida, and one each from Tennessee, Michigan, Indiana, Missouri, Minnesota, Wisconsin, New Jersey and Pennsylvania.

3.2. Hospital size

Sixteen studies (1–8, 10–15, 18 and 19) originated in large hospitals and university clinics or affiliated institutions, three in medium-sized ones (9, 16 and 17), and one in a small hospital (20).

3.3. Basic evaluation

The quantitative evaluation of the studies was made as described previously. The results are shown in Table 5. Two studies (9 and 17) achieved the highest score of 10, three (10, 11 and 12) had 7, two (15 and 19) 6, one (2) 5, five (1, 3, 5, 6 and 8) 4, six (4, 7, 14, 16, 18 and 20) 2 points. One study (13) achieved no points. No study obtained the point number of 1, 3, 8 and 9. Only 35% of the studies attained more than 5 points.

Table 5
Appraisal of the quality criteria

Number of study	Study	Year	Study design	Formal quality	Number of users	Running period	Statistical evaluation	Total score
1	Antoine [10]	2002	0	0	2	2	n.i	4
2	Asher [11]	2003	1	2	2	0	n.i	5
3	Blair [12]	2003	0	0	2	2	n.i	4
4	Fleisher [13]	1997	0	0	2	n.i	n.i	2
5	Fox [14]	1998	0	0	2	2	n.i	4
6	Hammond et al. [15]	1991	0	2	n.i	2	n.i	4
7	Kahl et al. [16]	1991	0	0	2	n.i	n.i	2
8	Kian et al. [17]	1995	0	0	2	2	n.i	4
9	Marill et al. [18]	1999	2	2	2	2	2	10
10	Myers et al. [19]	2000	0	2	2	2	1	7
11	Neubauer et al. [20]	2001	0	2	2	2	1	7
12	Pierpont and Thilgen [21]	1995	1	2	2	0	2	7
13	Sandrick 1 [22]	1998	0	0	n.i	n.i	n.i	0
14	Sandrick 2 [22]	1998	0	0	n.i	2	n.i	2
15	Sands et al. [23]	1998	0	2	2	2	n.i	6
16	Smith [24]	1997	0	0	2	0	n.i	2
17	Tierney et al. [25]	1993	2	2	2	2	2	10
18	Wall [26]	1998	0	0	n.i	2	n.i	2
19	Wells et al. [27]	2003	1	2	2	1	n.i	6
20	White and Hemby [28]	1997	0	0	n.i	2	n.i	2

n.i, no indication.

Two of the studies (9 and 17) are randomized controlled trials (evidence stages 2 and 3 of Table 4), three (2, 12 and 19) are non-randomized controlled trials (evidence stages 4–7 of Table 4), the remaining 15 are non-controlled clinical series, descriptive studies, consensus methods, application observations and empirical reports.

Nine studies (2, 6, 9, 10, 11, 12, 15, 17 and 19) consistently follow the internationally recognized structure of scientific articles and received 2 points each. The remaining 11 studies (1, 3, 4, 5, 7, 8, 13, 14, 16, 18 and 20) received no points.

Fifteen studies (1–5, 7–12, 15–17 and 19) have a user number of at least 20. Five of the studies (6, 13, 14, 18, and 20) have no information concerning their user number. Thirteen studies (1, 3, 5, 6, 8, 9, 10, 11, 14, 15, 17, 18, and 20) had a duration of at least one year, one study (19) of at least six months, four (2, 7, 12, and 16) under six months, and two (4 and 13) give no respective information.

Three studies (9, 12 and 17) supported their results by statistical tests with full information concerning the level of significance (cf. Table 6). Two further ones (10 and 11) indicated that they had used an undefined form of statistical analysis, fifteen (1–8, 13–16, 18, 19 and 20) gave no statistical details.

Table 6
Studies with statistical evaluation

Study	Year	Type of tests
Marill et al. [18]	1999	Significance, median, linear regression, Fisher's exact, Kappa coefficient, α-value and χ^2
Pierpont et al. [21]	1995	Significance/*p*-value/χ^2
Tierney et al. [25]	1993	Significance/*p*-value/variance

3.4. Main focus

All 20 studies are concerned with the economic aspects of the employment of an EPR. Nineteen of these studies indicate an economically positive impact, while only one (11) claims a monetary disadvantage of EPR. Four (1, 2, 6 and 12) of the 20 studies also deal with the effects on treatment quality. Sixteen studies are concerned exclusively with economic aspects and give no data on benefits for the patient.

The four studies (1, 2, 6 and 12) that consider both economic factors and treatment quality see an indirectly positive effect of treatment quality by increased exchange and flow of information between the monitoring and the administrative functions, compliance with the regulations and the ability to integrate graphic data such as electrocardiograms, alarms and warning systems, etc. In addition, improvements in data quality, data presentation, data availability, ease of production of data, reporting, data handling, access to reference materials, legibility, patient satisfaction, productivity of the doctor, reductions in incorrect medication and data input errors, quality assurance and training were reported. One of these four studies reports of a reduction in the mortality rate by the use of an EPR [15]. In their opinion, a prohibitively large numbers of patients would be needed to demonstrate that an EPR decreases mortality. They further argue: to demonstrate a 10% decrease in mortality rate in their cardiopulmonary unit, they would need 6000 test patients.

All publications document economic savings by the employment of an EPR within different areas (see Fig. 1). The main argument is reducing the amount of time required for administrative work, and in particular, archiving jobs such as searching, fetching, submitting, filing and maintenance of the paper-based patient records, as well as prescription and reporting. Eleven studies (1–5, 8, 10, 11, 13, 15 and 16) confirm this. Savings in the documentation costs are reported by six studies (6, 7, 8, 11, 12 and 20), among other things in data acquisition, and the production of tables and/or charts. Savings in nursing costs are reported in four studies (7, 8, 13 and 20). Clinical expenditures, such as nursing and medical supply, are mentioned in four studies (9, 11, 17 and 18). Savings in non-personnel costs are reported in two studies (3 and 16), savings in invoicing costs are reported in two studies (9 and 20), savings in drug expenses two studies (17 and 19) and savings in medical costs in one study (14). Two studies (8 and 11) provided cost-benefit comparisons as scenarios.

In one of these studies Neubauer et al. compared the direct economic costs of an EPR with its benefit, and determined a deficiency of approx. 42,000 DM annually [20]. This study considered the example of a university ophthalmic clinic with 140 plan beds, approx. 40,000 ambulatory treatments and approx. 36,000 bed days. The achieved benefit of an EPR was 192,000 DM per year. A four year write-off of essential additional equipment costs 234,000 DM annually. In this study it was also noticed that there were some advantages for research, teaching and quality assurance, reliable data access that were not directly quantifiable. These clearly exceed any negative aspects. Most of the non-quantifiable benefits referred in this study are shown in Table 7.

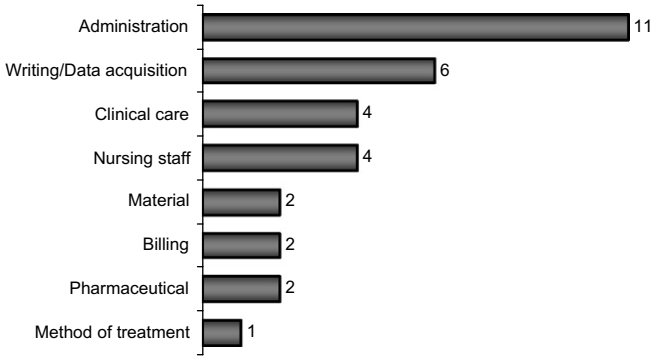

Fig. 1. Distribution of studies on types of cost reduction.

Table 7
Features, whose costs according to Neubauer et al. [20] are non-quantifiable

Region	Functions
Research and apprenticeship	Data pool for prospective and retrospective studies Disease processes and treatment results for training and further education Verification to activity of medical training and further education
Quality assurance	Review of documentation and treatment standards
Legal guidelines	Compliance of data security regulations Patient acquiescence and enlightenment Groundwork to judicial clarification
Economic use	Groundwork for internal profitability analysis

Kian et al. developed a prognosis for Cost Savings due to use of an EPR over ten years [17]. They estimated the quantifiable advantages of an EPR up to 2004, for example, in administrative activities, decision support, workflow optimization and administration. The savings for ten years were shown to be $129.69 million. The direct and indirect costs of hardware and software are estimated over a period of ten years as well, yielding a result of $54.49 million. The difference of $75.19 million is clearly on the side of a quantifiable benefit of an EPR.

4. Conclusion

The publications evaluated in this paper, document the current economic status of the employment of EPRs in different work areas. However, they offered no overall economic assessment from a national point of view. Especially concerning the influence of EPRs on quality of care, the studies do not provide a clear answer to the question of benefits. This might be due to the difficult setting which had to be evaluated in respective empirical studies. Missing MeSH terms concerning quality of care or wrong assignments of keywords in this area could have lead to a retrieval bias as well. Other limitations raise from the heterogeneous settings of the studies that were examined, since they cover a broad range of different EPRs, hospital sizes, etc. More qualified and more meaningful studies are thus essential to assess the overall impact of an EPR.

There is no doubt that an EPR has the potential to improve procedures, to reduce the problems of paper-based patient documents, to improve the treatment quality, to automate input requirements, and to improve quality control. Nevertheless, the real dimension of the improvement of treatment quality by EPR is not answered by the studies that were examined here.

Berger [29] concluded that the necessary technology would be offered widely, but there would be no demand by potential users. Hence the industry has made little effort in this direction. We can say today, the required technology is progressed widely, the demand continues to rise constantly. And industry is actively involved in the development of the EPR market.

According to Stausberg et al. [1] there is good evidence that intensive care documentation systems improve treatment quality, albeit with no concomitant cost reductions. The present study indicates the opposite: there is considerable evidence for a reduction of costs by the use of an EPR, but little sign of an improvement in treatment quality. The differing results may to be explained by the fact that in intensive care units the costs are relatively high and treat-

ment quality is always carefully monitored. Besides, the expenditures for administrative activities are not as high as in other supply areas, so that considerable savings cannot be made.

By order of the Agency for Healthcare Research and Quality (AHRQ) Chaudry et al. [2] systematically reviewed evidence on the costs and benefits associated with the use of health information technology and to identify gaps in the literature in order to provide organizations, policymakers, clinicians, and consumers an understanding of the effect of health information technology on clinical care (see the evidence report at www.ahrq.gov). By giving so many possible benefits and costs of implementing health information technology, they focus in their work on three important sectors: the effects of health information technology on quality, efficiency, and costs. They report that "... we found little information that could empower stakeholders to judge for themselves the financial effects of adoption. ..." In conclusion, they suggest four important future-oriented directions: (1) Additional studies need to evaluate commercially developed systems in community settings, and additional funding for such work may be needed. (2) More information is needed regarding the organizational change, workflow redesign, human factors, and project management issues involved with realizing benefits from health information technology. (3) A high priority must be the development of uniform standards for the reporting of research on implementation of health information technology. (4) Additional work is needed on interoperability and consumer health technologies, such as the personal health record. By the consideration of this review in comparison to our work, we recognize several identical predications e.g. in the conclusion. Nevertheless, for specific needs as administration and data acquisition we identified good evidence for significant positive effexts of EPRs.

The Evidence Report/Technology Assessment Number 132 "Costs and Benefits of Health Information Technology", which was prepared by Shekelle et al. [3] and provided Chaudry et al. [2] with a basis, copiously assesses the evidence base regarding the benefits and costs of HIT systems. It deals with numerous interesting aspects of HIT and gives several recommendations. Although its inclusion criteria were not as explicit as ours, most of its results concerning EHR Systems underline our conclusions: "The main quantifiable benefits of an EHR system were savings from data capture and access; decision support to improve efficiency, quality, and safety of care; business management related to staffing, billing, and overheads; and streamlining patient flow." They state further: "Multiperspective studies are needed to investigate the flow of costs and benefits in order to maximize the benefits of HIT in the larger healthcare delivery system."

Knaup et al. [4] summarize in their work current trends and major achievements in the field of electronic patient records and discuss its prospects, with a major focus on "Multiple use of data for e-health and e-research", "Architectures and technologies for patient record systems", "Standards for semantic interoperability" and "Integration of EPR systems into the hospital information system". Even though they extensively cover the objectives described above, their concrete statement on the costs and benefits of EPR systems is confined to "Reviewing the benefits and costs of EPR systems and the need for information systems strategic planning in order to adapt their functionality and quality to the needs of health care organizations has become more in focus these last years: help for efficient care and cost efficiency are prerequisites". With the review presented here we are able to close the knowledge gap mentioned by Knaup et al. [4] to some extend.

5. Update

Updating this study to 12 May 2006 yielded the following results: by applying the study selection rules as specified above under materials and methods, we obtained 133 studies for closer inspection. After reviewing the abstracts, 37 studies for literature procurement were left, four of which could not be obtained. The remaining 33 were examined in the second stage on the basis of the full texts under the criteria of concrete statements to benefits and costs. After conclusion of this appraisal procedure only two studies [30,31] still remained, which were entered into the analysis process. This scanty result of updating the main study indicates no new results up to 12 May 2006, leaving the conclusions drawn in the main body of this paper unaltered.

The two studies [30,31] evaluated state that using an EPR saves both physicians' time and personnel time, reduces transcription costs, and leads to fewer adverse drug events with lowered associated costs.

References

[1] Stausberg J, Uslu A, Schoch B. Die Elektronische Patientenakte in der Intensivmedizin: Anforderungen—Konzepte—Nutzen. In: Jäckel A, editor. Telemedizinführer Deutschland. Darmstadt: Minerva; 2004. p. 136–40.

[2] Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. Ann Intern Med 2006;144:742–52.

[3] Shekelle PG, Morton SC, Keeler EB. Costs and Benefits of Health Information Technology. Evidence Report/Technology Assessment No. 132. (Prepared by the Southern California Evidence-based Practice Center under Contract No. 290-02-0003.) AHRQ Publication No. 06-E006. Rockville, MD: Agency for Healthcare Research and Quality. April 2006.

[4] Knaup P, Bott O, Kohl C, Lovis C, Garde S. Electronic patient records: moving from islands and bridges towards electronic health records for continuity of care. Methods Inf Med 2007;46(Suppl. 1):34–46.

[5] Moormann PW, van der Lei J. An inventory of publications on computer-based medical records: an update. Methods Inf Med 2003;42(3):199–202.

[6] Waegemann CP. Current status of EPR developments in the US. In: Waegemann CP, editor. Toward an electronic health record´99. Newton MA: Medical Records Institute; 1999. p. 116–8.

[7] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33(1):159–74.

[8] Johnston ME, Langton KB, Haynes RB, Mathieu A. Effects of computer-based clinical decision support systems on clinician performance and patient outcome. Ann Intern Med 1994;120(2):135–42.
[9] Roine R, Ohinmaa A, Hailey D. Assessing telemedicine: a systematic review of the literature. CMAJ 2001;165(6):765–71.
[10] Antoine W. Electronic miracle—Memorial Hermann put its patient files online and watched its revenue grow. Health Forum Journal 2002;45(4):34–5.
[11] Asher JR. Time and money—a look at message automation via a computerized patient record. MGMA Connex 2003;3(9):28–9.
[12] Blair R. EMRs, quality of care and patient perception. Health Manag Technol 2003;24(11):38–41.
[13] Fleisher GR. What works, Children's Hospital ER automates records to save lives and money. Health Manag Technol 1997;18(4):37.
[14] Fox MR. What works, electronic repository saves $1 million plus. Health Manag Technol 1998;19(13):29.
[15] Hammond J, Johnson HM, Varas R, Ward CG. Qualitative comparison of paper flow sheets vs. a computer-based clinical information system. Chest 1991;99(1):155–7.
[16] Kahl K, Ivancin L, Fuhrmann M. Automated nursing documentation system provides a favorable return on investment. J Nurs Adm 1991;21(11):44–51.
[17] Kian LA, Stewart MW, Bagby C, Robertson J. Justifying the cost of a computer-based patient record. Healthc Financ Manage 1995;49(7):58–67.
[18] Marill KA, Gauharou ES, Nelson BK, Peterson MA, Curtis RL, Gonzalez MR. Prospective, randomized trial of template-assisted versus undirected written recording of physician records in the emergency department. Ann Emerg Med 1999 ;33(5):500–9.
[19] Myers DL, Burke KC, Burke Jr JD, Culp KS. An integrated data warehouse system: development, implementation, and early outcomes. Manag Care Interface 2000;13(3):68–72.
[20] Neubauer AS, Priglinger S, Ehrt O. Elektronische oder papiergebundene Patientenakte. Ein Kosten-Nutzen-Vergleich. Electronic versus paper-based patient records: a cost-benefit analysis. Ophthalmologe 2001;98(11):1083–7.
[21] Pierpont GL, Thilgen D. Effect of computerized charting on nursing activity in intensive care. Crit Care Med 1995;23(6):1067–73.
[22] Sandrick K. Calculating ROI for CPRs. Health Manag Technol 1998;19(6):16–20.
[23] Sands DZ, Rind DM, Vieira C, Safran C. Can a large institution go paperless? Medinfo 1988;9(1):60–3.
[24] Smith M. What works. Imaging saves Pascack Valley Hospital $ 200,000 a year not counting paper. Health Manag Technol 1997;18(4):38.
[25] Tierney WM, Miller ME, Overhage JM, McDonald CJ. Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. JAMA 1993;269(3):379–83.
[26] Wall TJ. The What Works awards. Three dramatically different solutions demonstrate creativity and effectiveness. Health Manag Technol 1998;19(1):12–6.
[27] Wells BJ, Lobel KD, Dickerson LM. Using the electronic medical record to enhance the use of combination drugs. Am J Med Qual 2003;18(4):147–9.
[28] White C, Hemby C. Automating the bedside. Healthc Inform 1997;14(2):68–74.
[29] Berger R. Telematik im Gesundheitswesen—Perspektiven der Telemedizin in Deutschland. Studie für das Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie und das Bundesministerium für Gesundheit, Available from: www.rolandberger.com; 1997 [accessed 25.09.04].
[30] Carpenter D. Three approaches to ROI. Hosp Health Netw 2005;79(5):9–12.
[31] O'Connor PJ, Crain AL, Rush WA, Sperl-Hillen JM, Gutenkauf JJ, Duncan JE. Impact of an electronic medical record on diabetes quality of care. Ann Fam Med 2005;3(3):300–6.